Journal of Island & Coastal Archaeology, 1:67–99, 2006

ISSN: 1556-4894 print / 1556-1828 online
DOI:10.1080/15564890600586283

Early State Formation in Southern Mesopotamia: Sea Levels, Shorelines, and Climate Change

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ABSTRACT

The evolution of the earliest complex state-level societies and cities from small sedentary communities took place in southern Mesopotamia between 8000 and 5000 cal yrs BP during the ʻUbaid and Uruk periods. Attempts to explain this transition often discount the role of environmental change and tend to evaluate available archaeological evidence for urban-based state development either within a static environmental context or assuming conditions similar to those of the present. This practice is no longer tenable given newly available paleoenvironmental records for the region. Post-glacial sea-level rise resulted in the inundation and creation of the Arabo-Persian Gulf, and, as the marine transgression slowed in the Middle Holocene, rich coastal and aquatic habitats formed in southern Mesopotamia. These habitats favored the establishment and growth of ʻUbaid Period communities and the efficient transport of goods, ideas, and people throughout the region. High water tables also promoted early experimentation with irrigation agriculture and the expansion of these systems as populations grew and the humid conditions of the Early Holocene gave way to increasing aridity. We argue that the critical confluence of eustatic and climatic changes unique to this circumscribed region favored the emergence of highly centralized, urban-based states.

Keywords paleoenvironment, sea-level rise, ʻUbaid, Uruk, Mesopotamia

Received 1 July 2005; accepted 1 December 2005.
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INTRODUCTION

Southern Mesopotamia was the site of the earliest large, highly integrated political systems marked by administrative hierarchies and rulers with significant power and authority—so called state-level societies (Rothman 2001, 2004). As states developed in this region, people became differentiated socially, more specialized economically, and highly integrated and centralized politically (Flannery 1972). This process resulted in greater interdependence and cooperation between members of society, but it also required a majority of people to relinquish autonomy and allow others to have greater economic, social, and political benefits. How and why this occurred in this region first, and later in several other locations around the world during the Middle and Late Holocene, remains a central question in anthropological archaeology (e.g., Adams 2000a; Algaze 2001a; Blanton et al. 1993; Feinman 2000; Feinman and Manzanilla 2000; Flannery 1998; Marcus and Feinman 1998; Pollock 1999; Postgate 1992; Rothman 2004; Stein 1998, 2001; Yoffee 2005).

Although there are indications for occupation earlier (see below), the first evidence of permanent human settlement in southern Mesopotamia can be traced to the beginning of the 'Ubaid Period at ~8000 BP. Between 8000–5500 BP, human populations increased and aggregated into small towns and nucleated villages. These communities ultimately provided the foundation for integrated state-level societies and urban centers that developed between 5500 and 5000 BP, with an associated complex of technological innovations including large-scale irrigation agriculture and writing. A number of theories have been proposed as to what stimulated formation of the earliest known state-level societies, including: (1) technological and agricultural innovation (Adams 1981, 2000b); (2) bureaucratic development necessary to build, maintain, and manage large-scale irrigation necessary for agriculture (Wittfogel 1957, 1981); (3) information processing and the development of centralization and political hierarchies (Wright 1977, 1994, 1998, 2001; Wright and Johnson, 1975, 1985); (4) increasing warfare in an environmentally and socially circumscribed area (Carneiro 1988); (5) increasing intra- and inter regional exchange, colonialism, and cross-cultural contact (Algaze 1993, 2001b; Wright and Johnson 1975); and (6) religious ideology and the control or mobilization of labor (Hole 1983). Proponents of multi-causal models suggest that state development resulted from several interrelated factors, including characteristics of the regional environment (Adams 1981; Algaze 2001a; Crawford 1991; Flannery 1972; Hole 1994; Kouchoukos 1999; Pournelle 2003; Redman 1978; Rothman 1994, 2004; Stein 1994, 2001; Wilkinson 2003). Others have suggested that state formation emerged as a result of intrinsic human social interrelations independent of environmental factors (Pollock 1992).

The processes leading to the emergence of state-level societies in southern Mesopotamia were multivariate, but we argue that these developments should be considered within the context of environmental change (Aqrawi 2001; Eisenhauer et al. 1992; Fairbanks 1989; Petit-Maire 1992; Sanlaville 1989; Sirocko et al. 1993; Teller et al. 2000). Changes in environmental conditions are often thought to have played a major role in cultural demise (Hodell et al. 1995; Issar 1995; Weiss 1997; Weiss et al. 1993). In contrast, the potential importance of climate and related environmental change is less accepted as a critical

variable in the development of cultural complexity, but has recently received increased attention (Hole 1994; Kennett and Kennett 2000; Sandweiss et al. 1999; Spier 1996). Except by Hole (1994; see also Nützel 2004), however, there has been limited consideration of the potential role of environmental change in the evolution of the state in southern Mesopotamia, where the environment has been incorrectly characterized by some archaeologists as stable during the Holocene (Pollock 1992). Evaluation of the available paleoenvironmental data demonstrates distinct correlations between the timing of Holocene environmental changes and cultural changes. These correlations, by themselves, do not prove causality but must be considered when evaluating the timing and nature of emergent cultural complexity in this region.

We propose that this development was stimulated, in part, by increased competition for resources caused by successive changes in sea-level, shorelines, and climate specific to this region. In particular, the expansion and ultimate stabilization of aquatic habitats associated with the marine transgression—habitats more productive than they are today—favored increased population densities and early group formation, community stability, enhanced maritime trade, and the emergence of social hierarchies. The natural diversity of resources in coastal/aquatic habitats, in combination with newly domesticated plants and animals, provided the economic foundation for these developing communities, as they did elsewhere during the Early and Middle Holocene (Binford 1968; Blake and Clark 1994; Moseley 1975). In this paper we describe these changes within the context of cultural development and discuss the possible implications of these interrelationships.

POSTGLACIAL ENVIRONMENTAL CHANGE IN SOUTHERN MESOPOTAMIA

Southern Mesopotamia lies in present-day southern Iraq at the head of the Arabo-Persian Gulf. Modern climatic conditions are arid to semi-arid, with a mean annual rainfall of 139 mm (ranging from 72 to 316 mm; Adams 1965). Severe dust storms occur during the summer months due to semi-permanent, low-pressure zones over the Gulf that draw hot, dry winds across the alluvial plain. Because of the region's extreme aridity, agriculture is limited largely to the floodplains of the Tigris-Euphrates-Karun rivers that converge in an extensive wetland region associated with the El Schatt Delta.

The Arabo-Persian Gulf is roughly 1,000 km long and ranges from 350 km to as little as 5 km wide at the Straits of Hormuz, where it joins the Gulf of Oman in the northern Indian Ocean. This is the shallowest inland sea of significant area in the world, the bathymetry reflecting a gently inclined basin with a mean depth of only 40 m and almost nowhere exceeding 100 m except near the Straits of Hormuz (Figure 1c) (Purser and Seibold 1973; Sarnthein 1971; Seibold and Vollbrecht 1969). Late Quaternary changes in sea level played a major role in shaping the environment of this region (Cooke 1987; Gunatilaka 1986; Sanlaville 1989; Teller et al. 2000). Although southern Mesopotamia is located on a subsiding sedimentary basin (Lees and Falcon 1952), tectonic influences on eustacy, including subsidence, are considered to have been relatively minor compared with glacioeustatic effects during the last 15,000 years (Aqrawi 2001; Cooke 1987; Gunatilaka 1986; Lambeck 1996; Macfadyen and Vita-Finzi 1978; Sanlaville 1989). This perspective differs

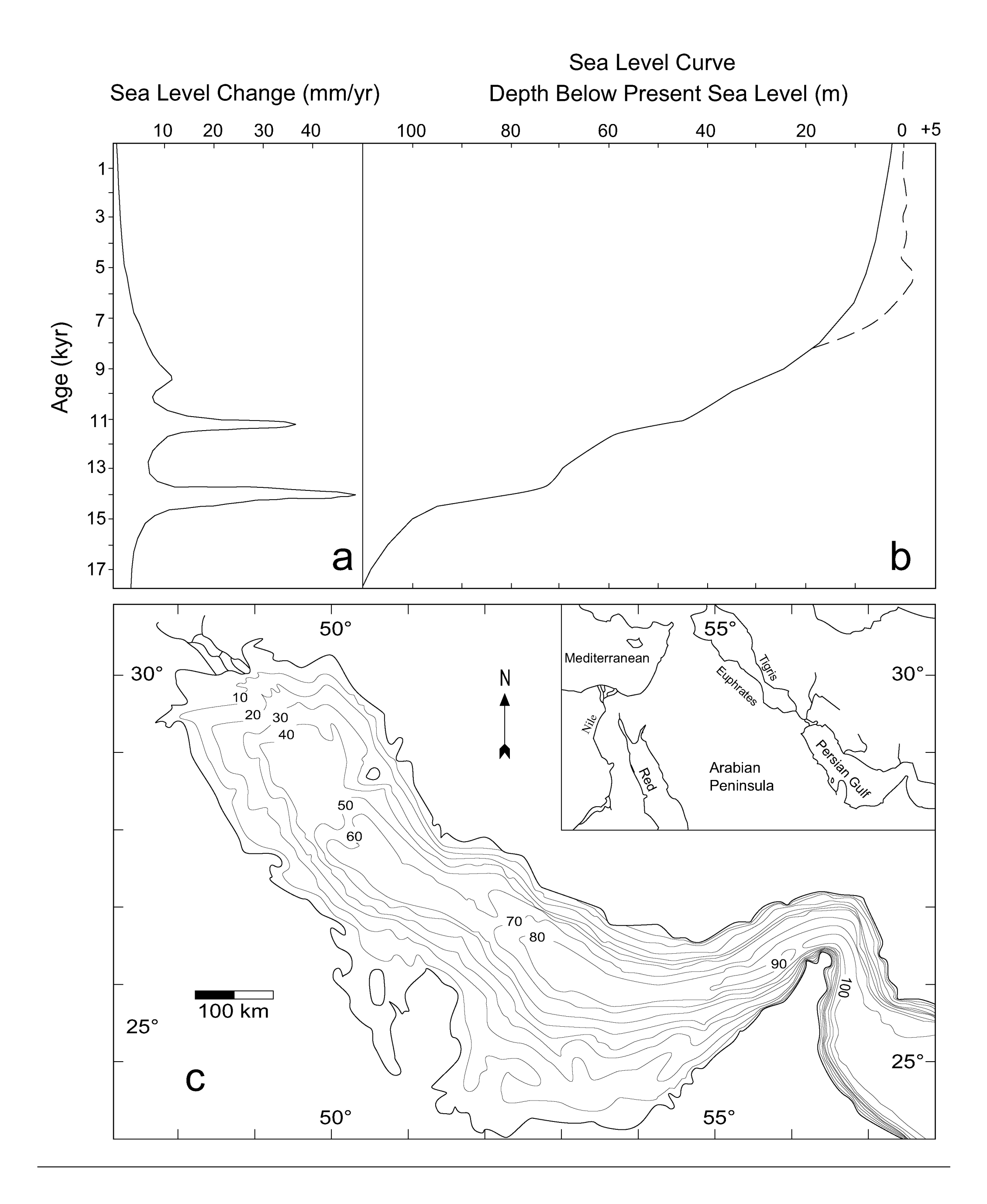


***Figure 1.** a, b: Sea-level change during the last 18,000 years (Fairbanks 1989; Lighty et al. 1982; Sanlaville 1989; Yafeng et al. 1993). Solid line in b shows well-established sea-level curve based on Caribbean corals (Fairbanks 1989; Lighty et al. 1982); dashed line is local sea-level curve estimated for northern Arabo-Persian Gulf (Sanlaville 1989; Yafeng et al. 1993). All radiocarbon dates have been calibrated to calendar years (BP). c: Modern bathymetry of the Arabo-Persian Gulf (adapted from Sarnthein 1972). (kyr = thousand years)*

from an earlier, widely accepted view that the balance between sedimentation and subsidence rates in southern Mesopotamia maintained the Gulf shoreline and delta close to their present-day positions throughout the Holocene and that inland incursions of the ocean resulted from subsidence (Lees and Falcon 1952).

Environmental conditions during the latest Pleistocene through Middle Holocene were different from those of today in southern Mesopotamia and the Gulf region. About 15,000 BP, global sea level was still 100 m below present (Figure 1a,b; Fairbanks 1989). Due to the shallowness of the Arabo-Persian Gulf, late Quaternary marine transgression associated with deglaciation was only beginning to enter this dry, subaerial basin through the Straits of Hormuz (Figure 2a; Lambeck 1996; Vita-Finzi 1978). Calcareous detritus in peri-coastal dunes in the United Arab Emirates was wind-transported from the exposed Gulf floor during the Late Pleistocene (100,000 to 12,000 BP; Teller et al. 2000). At this time, the Tigris-Euphrates-Karun River system flowed into the Gulf of Oman as the Ur-Schatt (ancient Schatt) River (Gunatilaka 1986; Seibold and Vollbrecht 1969), which traversed the full length of the Gulf in its deepest present-day sector. The Ur-Schatt River flowed in an incised canyon, now completely submerged, but still evident in the present-day bathymetry of the middle to lower Gulf (Sarnthein 1971; Seibold and Vollbrecht 1969). This canyon was formed by downcutting during low sea levels of the last glaciation. A deep-sea canyon extending southwards from the head of the Gulf of Oman (Seibold and Ulrich 1970) was almost certainly cut by turbidity currents carrying sediments southward. Large volumes of sediment appear to have been transported to the Gulf of Oman by the Ur-Schatt River during Quaternary low sea-level stands, implying substantial river flow. At this time, the modern delta did not exist in southern Mesopotamia (Figures 3) and narrow floodplains were restricted to the incised river canyons. Severe aridity at this time is indicated by the presence of drowned ridge and trough features in the northern Arabo-Persian Gulf, interpreted as fossil sand-dune fields (Sarnthein 1971), and supported by sedimentological (Diester-Haass 1973; Sarnthein 1972) and oxygen isotopic data (Sirocko et al. 1993).

After 15,000 BP, marine transgression formed the Arabo-Persian Gulf (Figure 2b–f). Sea-level rise during this interval was highly variable, but averaged ~1 cm per year until ~9000 BP (Figure 1a), after which the rate of rise slowed (Fairbanks 1989; Lighty et al. 1982; Warne and Stanley 1993). The pattern of global sea-level change after 9000 BP has yet to be firmly established. Sea-level curves from the western Atlantic (Lighty et al. 1982) and southeastern Mediterranean (Warne and Stanley 1993) show a slow rise with a steadily decreasing rate (average ~0.3 cm per year) from 7000 BP to the present (Figure 1b). In these curves, rates of rise are especially slow after 5500 BP. This pattern contrasts with sea-level rise estimates based on western Australian evidence of ~0.7 cm per year from 9800 BP to a maximum high stand at 6300 BP, followed by a slight decrease in sea level inferred to be associated with a cessation of polar ice-sheet melting (Eisenhauer et al. 1992). In spite of these differences, it is clear that the rate of global sea-level rise decreased significantly between 6300 and 5500 BP. Rapid rise in sea level during the early Holocene (Siddall et al. 2003) of ~1 cm per year created a lateral marine transgression in the Arabo-Persian Gulf of ~110 m per year, one of the highest rates known for any region. The early stages of

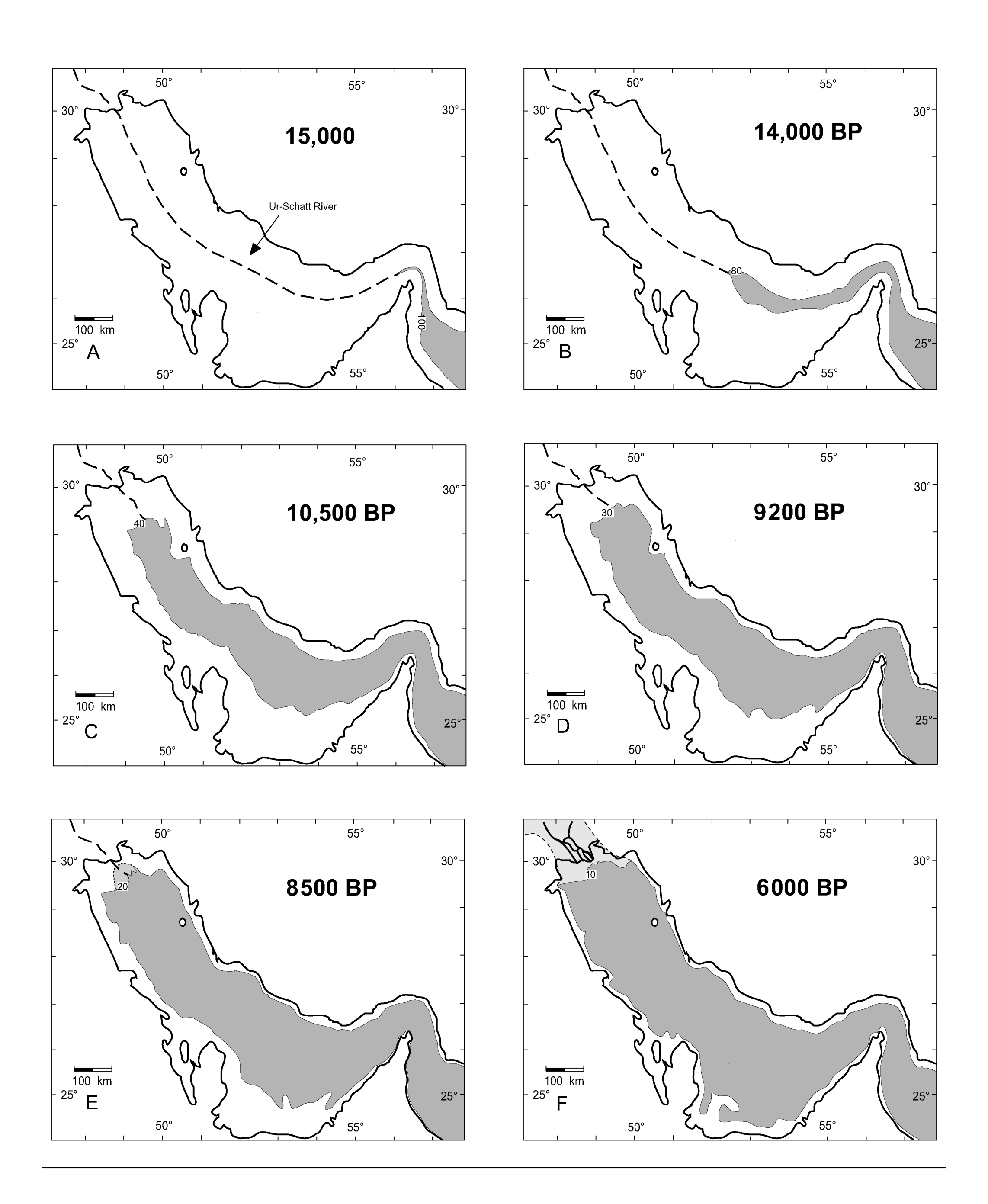


Figure 2. *Maps of successive time intervals showing the marine transgression into the Arabo-Persian Gulf during late Pleistocene-early/middle Holocene. Sea-level estimates from Fairbanks (1989) and based on modern bathymetry (Sarnthein 1972). Position of the Ur-Schatt River (ancient Schatt River) estimated from bathymetry (Sarnthein 1972). Marine transgression in southern Mesopotamia at 6000 BP (f) adapted from Sanlaville (1989) and shown in detail in Figure 4.*

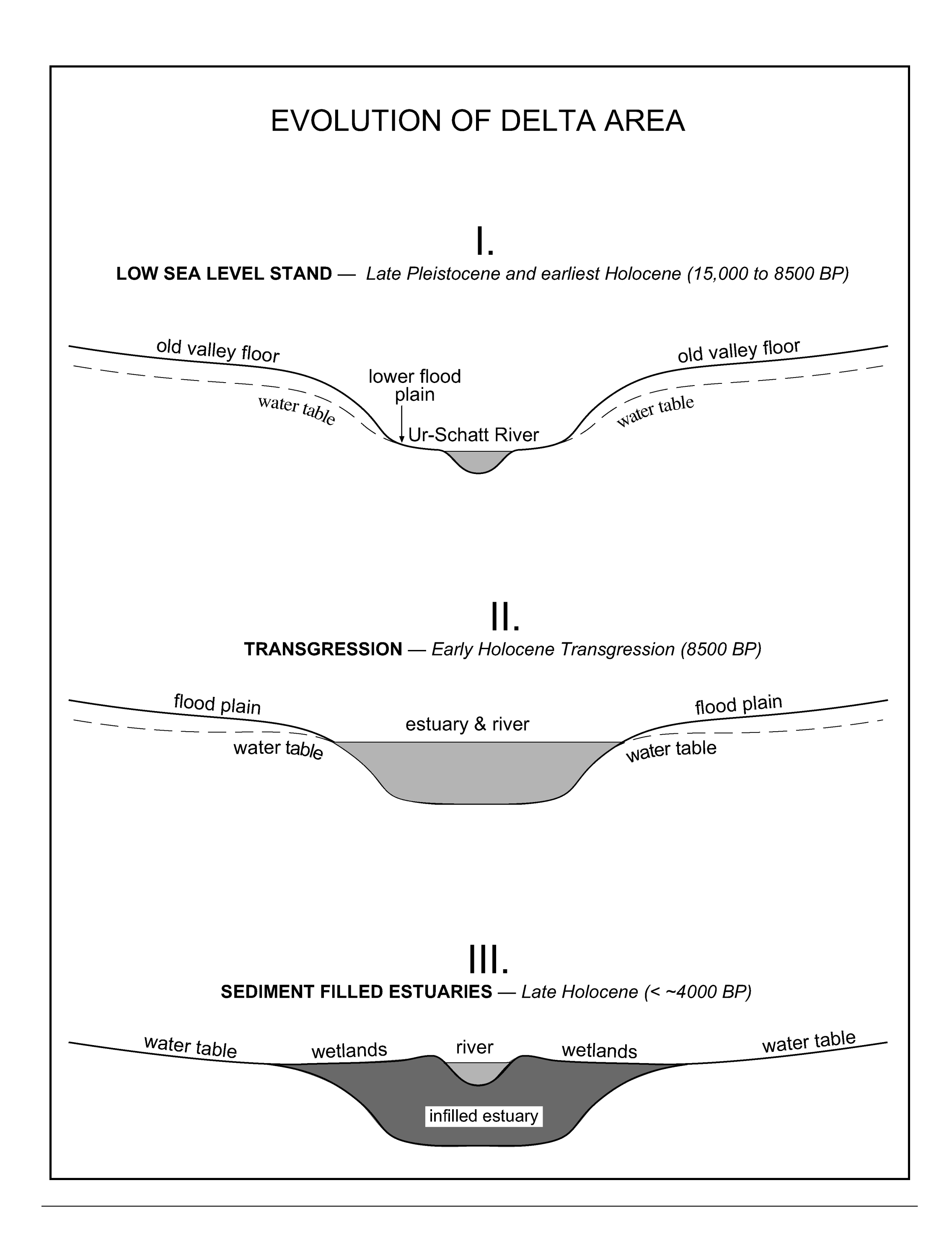


Figure 3. *Schematic cross sections showing inferred three stages in evolution of the delta region of southern Mesopotamia during the latest Quaternary.*

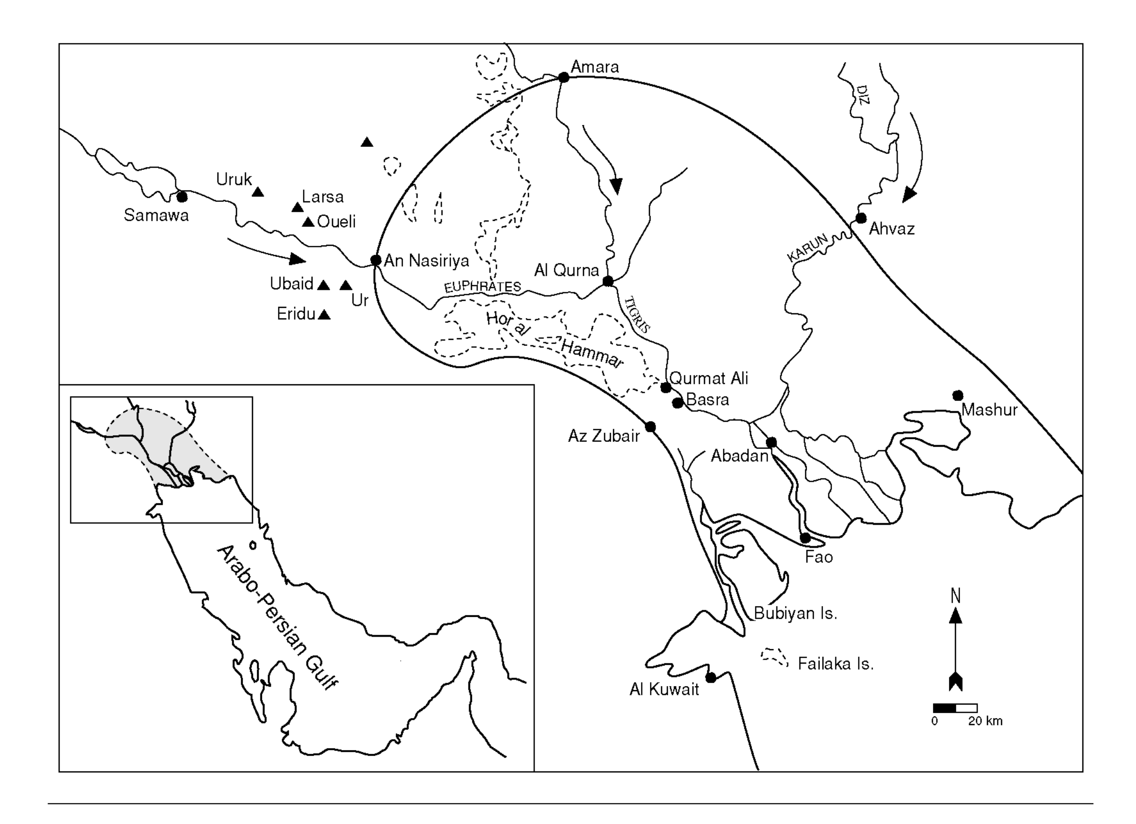


Figure 4. *Estimated shoreline at 6000 BP in southern Mesopotamia superimposed on present-day geography. Triangles show locations of early settlements and dots indicate modern cities (adapted from Sanlaville 1989).*

this transgression (~15,000 and 11,000 BP) filled mainly the deeply incised canyon of the Ur-Schatt River in its lower to middle reaches. The transgression later inundated the broader, shallower Gulf region (Figure 4). Most notable rapid rises in sea level in the Arabo-Persian Gulf occurred between 12,000 and 11,500 BP and again from 9500 to 8500 BP, and during these periods the lateral transgression probably exceeded 1 km per year (Teller et al. 2000: 306).[1]

Inundation of the Arabo-Persian Gulf coincided with an interval of increased seasonal rainfall across the Arabian Peninsula and southern Mesopotamia between ~10,000 and 6000 BP. This interpretation is based on a variety of indicators, including sedimentological evidence for increased river runoff into the Arabo-Persian Gulf (Diester-Haass 1973), speleothem records from Israel and Oman (Bar-Matthews et al. 1997; Burns et al. 1998, 2001), pollen evidence for more widespread, less arid vegetation, and the presence of inter-dune lakes on the Arabian Peninsula (Lézine et al. 1998; McClure 1976; Roberts and Wright 1993; Rossignol-Strick 1987; Street-Perrott and Roberts 1983) and in southern Mesopotamia (Wright 1993; Yan and Petit-Maire 1994) between 9000 to 6000 BP. Moister conditions

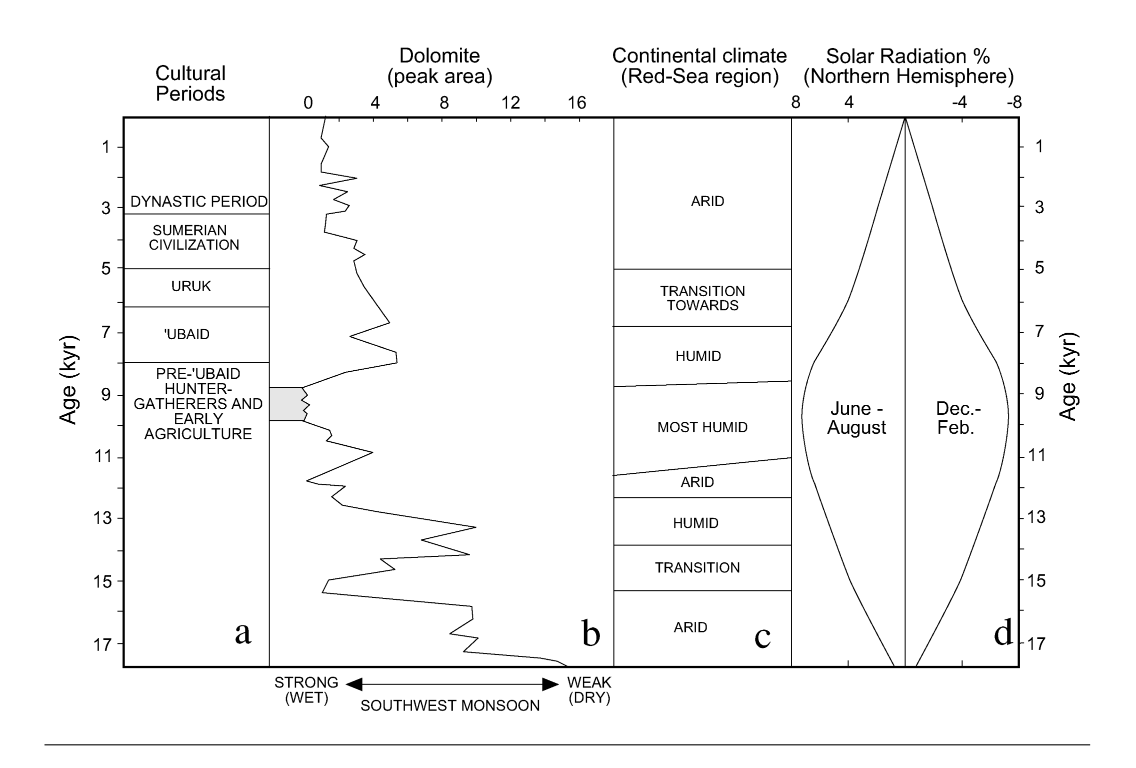


Figure 5. *Correlations between late Quaternary climatic changes (1000 BP = kyr; Almogi-Labin et al. 1991; Sirocko et al. 1993) and major cultural periods (a) in southern Mesopotamia (Adams and Nissen 1972; Rothman 2004; Wright and Rupley 2001; see also Endnote 2). Fluctuations in dolomite abundance (peak area) values (b) during late Quaternary in sediment core from Arabian Gulf reflect changes in aridity in Arabia–southern Mesopotamia region (Sirocko et al. 1993). The gray band on the dolomite curve represents interval of highest humidity. Shown at right is the percent change in solar radiation (d) in the Northern Hemisphere in summer (June–August) and winter (December–February) during the last 18,000 years, resulting from the earth's orbital perturbations (Kutzbach and Guetter 1986; Kutzbach and Gallimore 1988). This change caused summers to be warmer and winters colder in Arabia and southern Mesopotamia, with seasonal differences and inferred strength of summer monsoons peaking at ~9000–10,000 BP. Note relationship with humid-arid cycles in the Red Sea region (c), representing a synthesis of changes in lake levels, vegetation history, and sediment data (Almogi-Labin et al. 1991).*

are also inferred from an extensive network of ephemeral channels (wadis) over the Arabian Peninsula that run into the Arabo-Persian Gulf and Arabian Sea (Dabbagh et al. 1998; Hötzl et al. 1984) and appear to have been more active during the Late Pleistocene and Early Holocene (Wilkinson 2003). Increased rainfall in this region between ~10,000 and 8600 BP is also inferred from an absence of dolomite at this time in a sediment core from the Gulf of Oman (Sirocko et al. 1993) (Figure 5b). Under arid conditions, dolomite is formed in coastal, supra-tidal evaporitic environments (sabkas) in the Gulf region and wind-transported to the Gulf of Oman. Overall, Early Holocene

climatic conditions in Arabia were semiarid (~250–300 mm annual rainfall) compared with the aridity there today (50–100 mm annual rainfall) (Whitney et al. 1983).

Paleoceanographic and terrestrial climatic records in the Red Sea region indicate relatively humid conditions between ~12,000 and 6000 BP (Almogi-Labin et al. 1991), with the wettest interval occurring between ~10,000 and 7800 BP (Haynes et al. 1989; Street-Perrott and Perrott 1990; Figure 5c). A significant regional increase in rainfall between 11,700 and 5400 BP has also been inferred from a decrease in oxygen isotopic values in planktonic foraminifera and pteropods in a Red Sea core (21°N), interpreted to reflect decreased surface-water salinities (Rossignol-Strick 1987). The amount of continental freshwater runoff at this time was sufficiently large to decrease surface-water salinities in the Red Sea relative to present-day values. Inferred low salinities peaked between ~8500 and 6700 BP, then increased until 5400 BP, when average post-glacial values were reached (Rossignol-Strick 1987). Wet (humid) conditions between 9200 and 7250 BP in this region are confirmed based on increases in terrigenous sediment input and decreased surface-water salinities, as reflected by oxygen isotopes in foraminifera species in sediment cores from the northernmost Red Sea (Arz et al. 2003; see Figure 6). These data are consistent with pollen records and evidence for high lake levels, indicating Early Holocene (10,000–5500 BP) increases in precipitation and a pluvial maximum (~10,000–7000 BP) in the Levant (Issar 2003) and throughout sub-Saharan Africa (Ambrose and Sikes 1991; COHMAP 1988; Gasse et al. 1990, 1991; Haynes et al. 1989; Haynes and Mead 1987; Kutzbach and Street-Perrott 1985; Pachur and Kröpelin 1987, 1989; Petit-Maire 1986, 1990, 1992; Ritchie et al. 1985; Street-Perrott et al. 1985; Street-Perrott and Perrott 1990), coinciding with the so-called hypsithermal climatic interval (COHMAP 1988; Gasse et al. 1991; Kutzbach and Street-Perrot 1985; Lamb 1977; Petit-Maire 1986). Pollen (Lézine et al. 2002; Roberts and Wright 1993; Rossignol-Strick 1987), lake level (McClure 1976), and marine sediment (Diester-Haass 1973; Sirocko et al. 1993) data indicate that humid conditions persisted until ~6000 BP, although a gradual decrease in humidity had begun after ~8000 BP (Ritchie et al. 1985; Vita-Finzi 1978). Analysis of paleoclimatic data suggests that Southwest Indian monsoon strength for the broader Asia-East African region was greatest between 11,000 and 5000 BP (Overpeck et al. 1996), but in the Middle East, maximum activity seems to have occurred between 9000 and 7000 BP (Bar-Matthews et al. 1997; Lézine et al. 1998; Yan and Petit-Maire 1994).

The marine transgression reached the present-day northern Gulf area between 9000 and 8000 BP (Aqrawi 2001; Gunatilaka 1986; Lambeck 1996), inundating the entrenched Ur-Schatt River valley and forming an extensive marine estuary in the location of the present delta area. The modern delta has since filled the estuary (Aqrawi 2001; Cooke 1987). Movement of the coastline associated with the marine transgression was so rapid that sedimentation would have been minimal in the newly developing, open estuary and no delta would have formed (Cooke 1987). From ~9000 BP onward, and particularly after ~6000 to 5500 BP, sea-level rise slowed globally (Figure 1a,b; Fairbanks 1989; Lighty et al. 1982) or possibly reached a Holocene maximum at ~6000 BP (Eisenhauer et al. 1992; Yafeng et al. 1993). In the

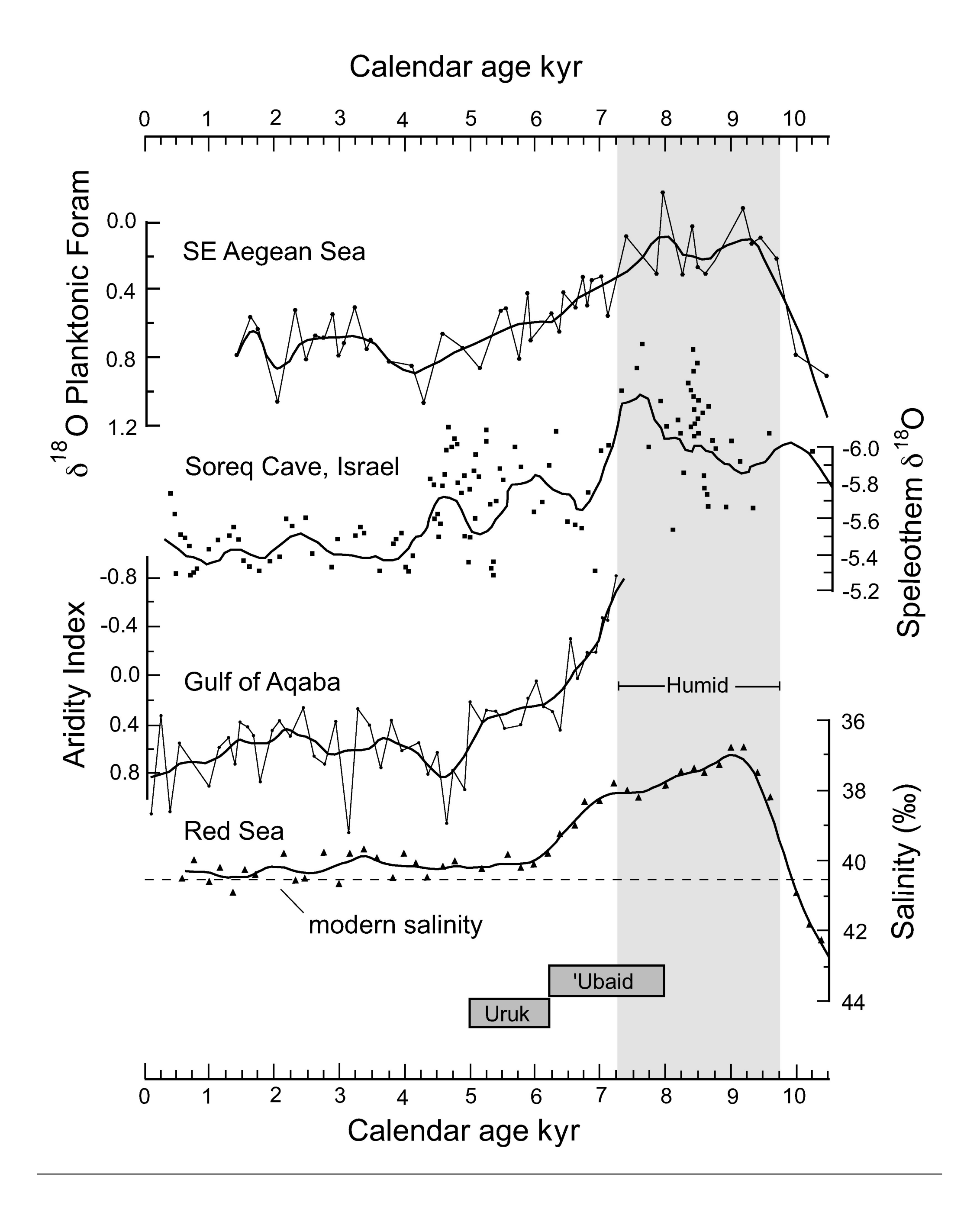


Figure 6. *Comparison of four climate records from the eastern Mediterranean–Red Sea regions showing early Holocene humidity and the onset of regional drying after ∼7000 BP (adapted from Arz et al. 2003). Major cultural periods shown at bottom of figure. (kyr = thousand years)*

northern Arabo-Persian Gulf, sea level reached its current elevation at 6000 BP, was possibly 2.5 m higher between 6000 and 5000 BP or longer (Lambeck 1996), and thereafter was relatively stable, close to present-day levels (Al-Asfour 1978; Sanlaville 1989). Sediments from boreholes in the Tigris-Euphrates Delta indicate marine-brackish conditions in the vicinity of Fao at ~9000 BP, near Basra at 8000 BP, and as far north as Nisiriyya by 6000 BP (Aqrawi 2001: 275). By ~6000 BP, estuaries had expanded to their northernmost limits. Marine deposits of 7000 BP age have been reported inland (80–100 km) at Lake Hammar, and estuarine deposits of this age are also known in cores 40 km farther to the northwest (Hudson et al. 1957; Sanlaville 1989). The northernmost known extent of estuarine sediments in boreholes of Holocene age is 400 km inland from the present head of the Gulf (Cooke 1987). Estuarine sediments from boreholes containing foraminifera, marine mollusks, and other marine fossils reflect brackish to marine conditions during the Middle Holocene near the ancient city of Ur on the Euphrates (Aqrawi 2001; Sanlaville 1989) and at Amarah on the Tigris (Aqrawi 2001; Macfadyen and Vita-Finzi 1978). Estuaries probably extended even farther northward following the Tigris-Euphrates-Karun River canyons and formed a variety of productive wetland habitats throughout this region (Pournelle 2003). Extensive floodplains and associated high water tables would have formed during the Middle Holocene with deceleration of sea-level rise as it began to approach present levels, with the consequent development of a complex mosaic of aquatic habitats (estuaries, rivers, wetlands, and marshes).[2]

By the Middle Holocene, regional climatic conditions had become more arid. This change is indicated by a diversity of evidence including an abrupt increase in aeolian sediment and dune formation on the southern periphery of the Arabo-Persian Gulf at 6000 BP (United Arab Emirates; Bray and Stokes 2004). Evidence from the Red Sea region indicates a marked trend toward increasing aridity between 7000 and 5000 BP (Almogi-Labin et al. 1991; Arz et al. 2003). Pronounced regional desiccation by 5000 BP dried up lakes in the region encompassing Arabia, the Red Sea, and sub-Saharan Africa (Almogi-Labin et al. 1991; McClure 1976; Pachur and Kröpelin 1989; Ritchie et al. 1985; Roberts and Wright 1993; Sukumar et al. 1993). Developing aridity also led to increased dust transport evident in the Arabian Sea after 5300 BP (Sirocko et al. 1993). In sub-Saharan Africa, lake level and pollen records also indicate that regional desiccation became widespread between 6000 and 5000 BP (deMenocal et al. 2000; Ritchie et al. 1985; Roberts 1989).

Major deceleration of sea-level rise after the Middle Holocene led to sediment infilling of the estuary, accelerated by erosion (Cooke 1987; Melguen 1973). Southeastward progradation of the Mesopotamian Delta commenced, eventually extending ~200 km to the southeast. This process led to the development of extensive wetland areas (Larsen and Evans 1978; Sanlaville 1989). The trend toward increasing aridity in the broad region continued through the Late Holocene. Aeolian deposits within deltaic sediments were most pronounced in southern Mesopotamia between 5000 and 4000 BP and point to severe aridity during this interval (Aqrawi 1993, 1995, 2001). Archaeological evidence for the abandonment of settlements also suggests that southern Mesopotamia became extremely arid during the Late Holocene (Nissen 1988; Weiss et al. 1993; Wright 1981). Flood levels in the Nile also declined between

5000 and 4000 BP (Roberts 1989) and central African rift lakes desiccated completely between 3400 and 3000 BP (Ambrose and Sikes 1991).

The changes in Holocene precipitation and associated shifts of the Sudanian-Sahelian vegetation belt over north Africa (Roberts 1989), the Arabian Peninsula, and southern Mesopotamia have been linked to changing intensification of summer monsoons related to northward shift of the Inter-tropical Convergence Zone and the influence of a more moist westerly airstream affecting the Mediterranean region (Clemens et al. 1996; COHMAP 1988; Kutzbach 1983; Kutzbach and Guetter 1986; Roberts and Wright 1993; Street-Perrott and Roberts 1983). Holocene fluctuations in the strength of the South Asian monsoon in the Middle East region resulted from differential thermal response of land and ocean surfaces due to orbitally caused (Milankovitch) changes in the strength of the seasonal cycle and solar radiation in the Northern Hemisphere (Clemens et al. 1996; Kutzbach and Gallimore 1988; Kutzbach and Guetter 1986). At 9000 BP, orbital perturbations of the earth were such that the perihelion occurred in July rather than January, as it does today, and the axial tilt of the earth was greater than it is now. As a result, July (summer) average solar radiation in the Northern Hemisphere was ~7% higher than today (Kutzbach and Gallimore 1988; Kutzbach and Guetter 1986). This additional radiation caused summers to be warmer and winters colder in Arabia and southern Mesopotamia, with seasonal differences peaking at ~9000 to 10,000 BP. The resulting increase in airflow over Arabia from the Indian Ocean, associated with southwest summer monsoons, led to higher seasonal precipitation (Kutzbach and Guetter 1986) and upwelling near south Arabia that peaked about 9000 BP (Prell 1984). Northern summer monsoons were stronger between 12,000 and 6000 BP in conjunction with increased summer radiation (COHMAP 1988). Associated summer monsoon precipitation over tropical lands increased ~10%–20% (Kutzbach and Guetter 1986). The broad arid-humid-arid cycle of the Middle East region during the last 18,000 years, including in southern Mesopotamia (Roberts and Wright 1993), was controlled largely by this change in the seasonal cycle. Increased monsoonal strength during the Early Holocene led to the higher annual precipitation as far north as southern Mesopotamia (Kutzbach and Gallimore 1988; Kutzbach and Guetter 1986; Roberts and Wright 1993; Whitney et al. 1983). Conditions further north remained relatively dry (Kutzbach and Guetter 1986; Roberts and Wright 1993). After ~5500 BP, weakening of the monsoons led to increasing aridity over the Arabian Peninsula (Sirocko et al. 1993).

STATE DEVELOPMENT IN SOUTHERN MESOPOTAMIA

States with well-developed urban centers and administrative hierarchies first appeared in southern Mesopotamia about 5000 BP (Late Uruk or LC5; Adams 1981; Johnson 1973; Nissen 1988, 2001; Pollock 1999; Postgate 1992; Rothman 2004; Wright and Johnson 1975; Yoffee 2005 [Figure 5a]). The people of southern Mesopotamia were on the leading edge of what Childe (1950) referred to as the second great revolution—the integration of large numbers of people into one social, economic, and political system ruled by an elite class with the help of an elaborate administrative hierarchy. Archaic states spread quickly in the Near East after this time and

developed independently in other parts of the world, including Mesoamerica, South America, and China (Feinman and Marcus 1998). The development of social differentiation, economic specialization, and ultimately political centralization culminating in the emergence of state-level societies is a central archaeological research question addressed from a variety of perspectives (Blanton et al. 1993; Feinman and Marcus 1998; Flannery 1972; Pollock 1999). Southern Mesopotamia has played an important role in the modeling of state origins and the emergence of centralized administrative hierarchies because of the long tradition of research in the region (Rothman 2004; Yoffee 2005).

Origins of the first city dwellers in southern Mesopotamia have long been debated and are crucial for understanding the social, economic, and political processes culminating in the state (see Bottéro 2001; Frankfort 1956; Kramer 1963; Meissner 1920; Oates 1991; Potts 1997; Speiser 1930). Similarities of architecture and ceramic styles in southern Mesopotamia from the Early 'Ubaid through Late Uruk periods (~8000 to 5000 BP) suggest a certain degree of demographic and cultural continuity, rather than the intrusion of outside peoples, prior to the emergence of the state (Oates 1960). Population continuity is also indicated by a series of superimposed temples at the site of Eridu during this interval (Oates 1960; Potts 1997:47). This was the period when some small villages grew in size relative to neighboring settlements and ultimately became the first state centers in which social and political hierarchies developed.

The settlement history of people in southern Mesopotamia prior to 8000 BP is far from clear. A transition from mobile hunting and gathering to sedentary agriculture is evident in west Asia between 12,000 and 8000 BP (Bar-Yosef and Belfer-Cohen 1989; Bar-Yosef and Meadow 1995; Flannery 1969; Garrard 1999; Harris 1996, 1998; Henry 1989; McCorriston and Hole 1991; Meadow 1996; Zeder and Hesse 2000). This was a time of early development of agriculture and animal domestication (Smith 1998); emergence of small villages, some of which were fortified; and pottery manufacturing in various locations (Redman 1978). Early agricultural villages in northern Mesopotamia (e.g., Tell es-Sawwan) were generally limited in size to a few hundred people engaged in simple agriculture and animal domestication (Moore 1985). We suspect that at this time people were living along the Ur-Schatt and associated floodplains, a natural corridor connecting northern Mesopotamia with the interior shallow basin known today as the Arabo-Persian Gulf. This basin was then undergoing rapid marine transgression and stories resulting from this inundation may be the source of biblical flood mythology (Potts 1996; Teller et al. 2000). Evidence for settlements along the Ur-Schatt River has since been obscured by flooding and/or covered by sediments.

Some archaeological evidence exists for a pre-'Ubaid occupation along the northeast coast of the Arabo-Persian Gulf. Furthermore, Neolithic stone-tool assemblages (Arabian bifacial tradition; Potts 1997:52) dating to between 9600 and 5500 BP are also common near now-desiccated inland lakes across the Arabian Peninsula (Edens 1982; Edens and Wilkinson 1998; Potts 1993, 1997; Uerpmann 1992; Zarins et al. 1981) and at several locations along the western edge of the Arabo-Persian Gulf by at least 7300 BP (Beech et al. 2005; Connan et al. 2005; Glover 1998). Visible architecture is rarely encountered at Arabian Neolithic sites, with the exception of small stone structures reported at several coastal locations (e.g., Kuwait

[Connan et al. 2005]; Qatar [Inizan 1988]; Marawah Island, United Arab Emirates [Beech et al. 2005]). Artifact and faunal/floral assemblages from these sites suggest that people combined sheep and goat herding with small-game hunting, the collection of local grasses, and even periodic cereal-crop farming (Potts 1993, 1997). This form of subsistence was combined with fishing, shellfishing and other marine resources (e.g., sea turtles; Beech et al. 2005) at several sites along the Arabo-Persian Gulf (Connan et al. 2005; Glover 1998). These data indicate a mixed foraging and food-producing strategy comparable to what Smith (2001) has described as low-level food production. Stone tool assemblages dating to ~8000 BP are also known from wadi systems in western Iraq that flow into the Euphrates River (Zarins 1990). Similar stone tool assemblages, although poorly described, are documented in southern Mesopotamia (Potts 1997:53; Zarins 1992), where they were found at Ur (Woolley 1955), near Eridu (Potts 1997), and at Tell Oueli and Tello (Cauvin 1979; Inizan and Tixier 1983). Pre-ceramic sites on the eastern fringe of southern Mesopotamia (Tell Rihan III in the Hamrin and Choga Banut in Kuzistan) dating to ~8500 BP also suggest linkages between people living in the Zagros and in the southern alluvium (Aurenche 1987). Overall, the archaeological record for this period suggests that significant populations lived across the desert regions of Arabia and Mesopotamia, practicing a diverse range of subsistence strategies tied to a variety of aquatic habitats (e.g., lakes, springs, creeks, rivers) resulting from the northward shift of the south Asian monsoon belt during the Early to Middle Holocene.

The presence of stone tools comparable to the southern Arabian biface tradition is consistent with the idea of a pre-'Ubaid occupation earlier than 8000 BP in southern Mesopotamia (see Oates 1960, 2004). Exploration for pre-'Ubaid sites is impeded by thick alluvial sediments deposited since the near-stabilization of sea level at ~6200 BP and a water table that is higher than when sites of this age were occupied. Even early 'Ubaid sites in the region (e.g., Hajji Muhammad) are deeply buried under alluvium (Huot 1989), so it is likely that sites of this age are more numerous. Several sites are now known to contain pre-'Ubaid ceramics comparable in form to Samarran and Choga Mami assemblages from central and northern Mesopotamia (WS 298 [Adams and Nissen 1972] and Tell Oueli [Calvet 1989; Huot 1989; see also Potts 1997]). Tell Oueli is the most impressive of these sites, with early levels, now designated as Ubaid 0 (~8000 BP; Oates 2004), that are 5 m thick in places and contain ceramics and cigar-shaped building bricks reminiscent of those from cultural traditions in northern and central Mesopotamia (Huot 1989). These findings are consistent with the idea of a small, relatively sedentary population living around wetlands at the head of the Arabo-Persian Gulf as sea-level rise slowed. Whether they moved into this area as sea level was stabilizing or were pushed from the south with rapid sea-level rise remains unresolved, but if biblical flood mythology originates in southern Mesopotamia, it is likely that at least a portion of the resident population on the floodplains of the Ur-Schatt River were displaced to the north because of this marine transgression (Potts 1996; Teller et al. 2000).

By the beginning of the 'Ubaid Period (~8000 BP), small villages and towns were more common across greater Mesopotamia. Much of this region was linked through social networks, and similarities in artifacts

indicate widespread exchange of goods and knowledge. The archaeological record suggests distinctive demographic trends in southern Mesopotamia and the Susiana Plain during this time. Larger numbers of known settlements dating to the early 'Ubaid Period result from a combination of greater archaeological visibility (larger sites visible above alluvium), and increases in regional population. At this time the communities of Eridu, 'Usaila, Ur, and Tell al-'Ubaid were small, averaging about one hectare in size, with estimated populations seldom exceeding 1,000 people. These small communities were widely dispersed and lacked the linear distribution typical of settlements dependent on irrigation canals (Adams 1981:59), although irrigation agriculture was practiced elsewhere in Mesopotamia and was employed in some parts of the southern alluvial plain (Oates and Oates 1976; Wilkinson 2003). The carbonized remains of *Triticum monococcum* (einkorn) and *Hordeum vogare* (barley) in 'Ubaid 0 (~8000–7500 BP) levels at Tell Oueli also suggest that some form of irrigation was in use (Huot 1989, 1996), or that the higher humidity evident in Early Holocene climate records was sufficient to sustain rain-fed agriculture, perhaps in combination with opportunistic use of seasonally receding flood zones or the higher water tables close to the head of the Gulf (Kouchoukos 1999). Early settlements were located on slight rises (turtle backs) within aquatic habitats resulting from seasonal monsoonal rains or in the wetlands at the head of the Arabo-Persian Gulf as sea-level rise slowed (Pournelle 2003). Such locations were at the interface between fresh and salt water and were optimal for fresh water accessibility, hunting/fishing, transportation, and irrigation agriculture (Oates 1960). Within this aquatic context, a broad-spectrum economy developed during the 'Ubaid Period, based upon small-scale agriculture with an emphasis on salt-tolerant crops, animal (e.g., oxen) domestication, hunting, fishing, and trade (Huot 1989; Sanlaville 1989; Woolley 1929:14).

By middle 'Ubaid times ('Ubaid 2–3), some communities in southern Mesopotamia and grown larger than their neighbors, a two-tiered settlement system that often marks the emergence of hierarchically organized (non-state) societies (Stein 1994; Wright 1981). Important centers included Eridu, Ur, and Uquir (Adams 1981; Wright 1981; Wright and Pollock 1986). Eridu and Ur were particularly large by this time, both having grown to between 9 and 10 ha in size and with estimated populations of 2,000 to 3,000 people (Adams 1981). A similar pattern occurred on the adjacent Susiana Plain (in southwestern Iran), where Choga Mish expanded rapidly to 11 ha, dwarfing other agricultural communities in the region (Wright and Johnson 1985). As some communities expanded in size within the Mesopotamian heartland, 'Ubaid Period ceramics appear in Neolithic settlements and shell middens along the east coast of the Arabian Peninsula (Glover 1998; Masry 1974; Oates et al. 1977; Potts 1993; Uerpmann and Uerpmann 1996; Zarins et al. 1981). The appearance of 'Ubaid Period ceramics is associated with the first evidence for a maritime trade network, suggested by the remains of a barnacle-covered reed and bituminous boat from coastal Kuwait (Site H3, As-Sabiyah; 'Ubaid 3, 7300–6900 BP; Carter 2002, 2003; Connan et al. 2005). Population expansion continued across the southern Mesopotamian alluvium in late 'Ubaid times ('Ubaid 3–4) and a network of large and small settlements developed with economies based on irrigation agriculture (Wright 1981; Wright and Pollock 1986). With this

expansion, elements of material culture associated with the 'Ubaid Period (e.g., uniform pottery style [Berman 1994]; other clay objects and cone-head figurines, sickles, and "nails" [Roaf 1984; Wright and Pollock 1986]; and architecture [Huot 1989]) first appear in northern Mesopotamia (Rothman 2002; Stein 1994; Tobler 1950), a pattern interpreted as political integration centered on the southern alluvium (Algaze 1993) or cultural replication due to contact with people to the south (Stein 1994). Interestingly, there is little evidence for warfare in southern Mesopotamia until the end of the 'Ubaid Period. Settlements were not fortified and 'Ubaid seals do not show war-related depictions. In contrast, warfare in northern Mesopotamia during this period is suggested by the presence of fortified settlements and interpreted as evidence for intrusive 'Ubaid expansion from the south (Stein 1994).

The distribution of wealth items within 'Ubaid Period sites is suggestive of differential access to economic benefits (Stein 1994). Economic and political differentiation is also indicated by the hierarchical distribution of settlements, a pattern first visible during the middle 'Ubaid Period (Wright 1981). Unlike in hierarchical societies that developed in other parts of the world (Clark and Blake 1994; Clark and Pye 2000; Earle 1987; Flannery 1968), little evidence exists to support elite control of long-distance exchange systems and centralized control of high-status craft production (Stein 1994). Mortuary studies also provide little evidence for social ranking and depictions of rulers are rare (Stein 1994; Wright and Pollock 1986). Instead, 'Ubaid Period society was centered on the temple complex, and ideology appears to have played an important organizing role in these communities (Hole 1994:139; Stein 1994). These temples occur at focal settlements throughout the region, a pattern that remained remarkably stable for 1,500 years (Stein 1994). Temples were rectangular in form, oriented to the cardinal directions, and contained altars and offering tables. A series of superimposed temples excavated at the important center of Eridu suggests continuity in settlement and social organization at this location throughout the 'Ubaid Period (Oates 1960). The first temple in this sequence was constructed during the 'Ubaid 1 phase and subsequent temples were larger and more elaborate. Offerings associated with these temples indicate that aquatic resources (e.g., fish) played a central role in this society (Bottéro 2001). The economic importance of estuarine and riverine fish is also indicated by faunal remains in 'Ubaid 4 levels at Tell Oueli (Huot 1989). It is possible that the ideological system represented by the 'Ubaid temple complex was used to legitimize differential access to key elements of the farming system (e.g., water, land, and labor; Stein 1994) as people began to intensify agricultural production to sustain larger populations in the region. Stein (1994) has argued that ideological manipulation was used to mobilize food surpluses to storage facilities at focal communities, based on the large size of territories during the late 'Ubaid Period and some evidence for centralized storage facilities at Tell Oueli (Huot 1989). Regardless, by the end of the 'Ubaid Period (~6300 BP),[3] it is clear that some communities were substantially larger than their neighbors, were ruled by hereditary leaders, and were administered by institutionalized administrative organizations.

The economic, social, and political complexity evident at the end of the 'Ubaid Period culminated during the Uruk Period (6300–5000 BP) with the development of the first urban-based

states at ~5000 BP (Late Uruk or LC5 [Adams 1981; Johnson 1973; Rothman 2004; Wright and Johnson 1975]). A significant population expansion occurred in southern Mesopotamia during the 'Ubaid to Uruk Period transition (~6300 BP), but some areas (northern alluvium) saw population decline as settlements became more concentrated in the southern alluvium (Adams 1981:60–61). The city of Uruk-Warka, with deposits extending back into the 'Ubaid Period, was the largest and certainly the most prominent city on the southern alluvium through the Uruk Period (Nissen 2001). This community grew to 250 ha by the end of the Uruk Period and the urban core expanded to 100 ha in size (Finkbeiner 1991; Nissen 2001), with an estimated 10,000 inhabitants (Redman 1978). Most of the elaborate public buildings at Uruk-Warka date to the Late Uruk Period (3–5) and reflect a development of complex administrative systems over the course of about 600 years (Nissen 2001). The increased size of Uruk-Warka resulted from indigenous population growth (Johnson 1988–89) or migration of people from adjacent areas. This occurred as communities were abandoned further to the north in southern Mesopotamia and the adjacent Susiana Plain (Adams 1981; Johnson 1973), perhaps fostered by increasing aridity evident throughout the region or due to deltaic progradation.

Uruk-Warka was the largest urban center in southern Mesopotamia by the Late Uruk Period (Nissen 2001), dwarfing even the large settlement of Susa on the adjacent Susiana Plain (~18 ha; Hole 1987). The urban core of this city was surrounded by a defensive wall and divided into two discrete areas, each containing large, free-standing buildings visible from a considerable distance (Heinrich 1982; Nissen 2001). Some of these large structures are interpreted as public buildings representing temples, "cult houses," or assembly halls (Heinrich 1982; Nissen 2001; Schmid 1980). Cylinder seals and clay tablets found in dumps behind administrative buildings represent the first writing systems and appear to have been used primarily for information storage and accounting purposes (Nissen et al. 1993). A vigorous economy is suggested by the remains of workshops and kilns in the city center, and substantial evidence exists for craft specialization, with major advances in metallurgy and pottery manufacture visible in the record (e.g., fast wheel; Adams and Nissen 1972). Artistic achievement also flourished. Clear social and political hierarchies are indicated by artistic representations and by a clay tablet containing a "standard professions list," a categorization of professions from rulers to laborers (Nissen 2000; Nissen et al. 1993). This list indicates that a strong division of labor was well established and that the hierarchical elements of society likely had roots earlier in the 'Ubaid and Uruk Periods. A strong political authority is also suggested by hints of forced labor and the control of an extensive agricultural irrigation system. This authority is also indicated by rank-size differences between communities and evidence from cylinder seals showing strong economic, political, and social integration between cities and smaller communities in the region (Wright and Johnson 1975). Other large cities in the region dating to this time include Kish, Nippur, Gersu, and Ur (Nissen 2001).

The southern cities of Mesopotamia were linked to other communities in greater Mesopotamia via exchange networks. These networks were crucial for state development because people living on the southern alluvium were able to acquire goods unavailable locally (e.g., high-grade wood and metal; Algaze 1993). By the late Uruk Period, the

movement of goods to southern cities was facilitated by outposts strategically located in areas containing valuable resources or close to natural trade routes, affording control over the distribution of these materials (e.g., Godin Tepe, Habub Kabira, Hacinebi Tepe, Jabal Aruda [Algaze 2001b; Rothman 2001]). The records at these sites suggest that colonists/merchants from southern Mesopotamia were able to gain access to critical materials and wealth objects necessary to support the emerging social hierarchy in the heartland. This trend occurred during the Late Uruk Period between about 5500 and 5000 BP and is known as the Uruk expansion (Algaze 1993, 2001b; Wright and Rupley 2001). Algaze (2001b) argued convincingly that the process of state development was linked to broader economic interactions that helped enable leaders to sustain the development of economic, social, and political hierarchies in southern Mesopotamia.

DISCUSSION

In southern Mesopotamia the cultural changes leading to integrated state-level societies occurred during a 3000-year period between the beginning of the ‘Ubaid Period at ~8000 BP and the end of the Uruk Period at about 5000 BP. Although states flourished after 5000 BP, during the Sumerian Period, the foundations were built during the ‘Ubaid (8000–6300 BP) and Uruk (6300–5000 BP) periods. This was a dynamic interval of human cultural evolution, a punctuated series of events, in a long (~80,000 years; Klein 1999) history of human hunting and gathering and early agricultural economies (Early Holocene; Moore 1985). The first urban-based states appeared in southern Mesopotamia and the Susiana Plain, although early sedentary agricultural communities and hunter-gatherers were then well distributed throughout much of the region. We suggest that state development in southern Mesopotamia resulted from human responses stimulated, in part, by a particular succession and confluence of environmental changes unique to this region during the Early and Middle Holocene. Rapid and extensive marine transgression, coupled with higher rainfall, was followed by stabilization of sea level and increasing aridity. Interrelated human responses resulted in intense and increasing competition for favorable resources that were becoming increasingly circumscribed due to aridity and population expansion (Carneiro 1988; Flannery 1972; Service 1978). These changing conditions favored population aggregation, and intensified agricultural production, economic specialization, and the formation of social and political hierarchies founded on and reinforced by new or existing ideological systems. In this context, the first urban centers emerged and controlled adjacent communities with elaborate and centralized administrative hierarchies led by a small, elite class.

Our hypothesis includes elements of previous models that incorporated several interrelated factors: population increase, environmental and social circumscription, increased warfare, development of extensive irrigation agriculture, and favorable conditions for trade (Haas 1982; Rothman 2004). Nevertheless, we argue that any explanation is incomplete if it considers these factors, alone or in combination, in the absence of environmental change. Population increase was a necessary component for the development of state-level societies, but by itself was inadequate (Adams 1981; Wright and Johnson 1975). Similarly, state development was possibly the cause rather

than the result of large-scale irrigation agriculture and increasing inter-regional trade (Adams 1974; Wright and Johnson 1975). However, large-scale irrigation could not have occurred in this region without sufficiently high, near-stable sea levels necessary for the development of extensive floodplains at river level and a high water table.

Relatively few researchers have stressed climate change as an important factor contributing to the development of city-based states in southern Mesopotamia. Exceptions are Hole (1994), Nissen (1988), and Sirocko et al. (1993), who suggested that state development was tied to increased regional aridity during the Middle Holocene. Hole (1994) stressed the importance of climatic instability as a major trigger in cultural development, suggesting that short-term environmental shocks encouraged collective action to mitigate them. Sea-level change has also been considered to have caused human migrations and to have strongly influenced the development of agrarian economies (Ryan and Pitman 1998; Stanley and Warne 1993; Van Andel 1989). Recent work in Egypt has linked deceleration of global sea-level rise between 8500 and 7500 BP with the formation of the Nile Delta and the initiation of farming settlements (Stanley and Chen 1996; Stanley and Warne 1993, 1997). Hole (1994) considered sea-level rise to be insignificant for cultural development in southern Mesopotamia, however, arguing that whereas sea-level rise was too slow for river aggradation to keep pace, stability of the land surface fostered the extensive use of canal systems and aggregated settlement.

Our view is that climatically induced environmental change is one of several variables leading to the emergence of centralized states in this region. Given the coincidence of major climatic shifts and the emergence of social hierarchies and centralized states, these physical factors should weigh more heavily than other variables that are more difficult to document quantitatively. We argue that certain behaviors were favored (probabilistically, not deterministically) within this dynamically changing environmental and social context and that they had major evolutionary implications for the formation of social hierarchies and ultimately the institutionalized administrative hierarchies characteristic of urban-based states (see Winterhalder and Goland 1997 for a similar argument with respect to agricultural origins). Therefore, we emphasize decision-making or human responses to a changing set of environmental and social circumstances in southern Mesopotamia in three distinct, but continuous stages.

Stage I: 9000 to 8000 BP. Little is known about cultural development during the pre-'Ubaid Period of southern Mesopotamia because populations were likely small and dispersed and the archaeological record is either covered by water and/or buried by alluvium deposited during floodplain aggradation. We suggest that Early Holocene climatic conditions between 9000 and 8000 BP were an important catalyst for later cultural developments. Climatically this period was the most propitious for people living in this region because of higher humidity and more reliable summer monsoon rainfall (Arz et al. 2003; Petit-Maire et al. 1997). Widely distributed lakes in northern Arabia and southern Mesopotamia, created by seasonal monsoonal conditions, would have favored dispersed settlement and seasonal mobility. The wadi systems of northern Iraq and the floodplains along the Ur-Schatt River provided localized aquatic resources attractive to early populations.

Sparsely distributed stone tools characteristic of the Arabian bifacial tradition provide tantalizing evidence for pre-'Ubaid occupation in the southern Mesopotamia Delta region (Cauvin 1979; Inizan and Tixier 1983; Woolley 1955; Zarins 1992). These data are consistent with other evidence from along the northeast coast of the Arabo-Persian Gulf and more broadly across the Arabian Peninsula for small preceramic settlements near now-dry lakebeds dating to between ~9600 and 7000 BP (Potts 1993). Evidence suggests that people practiced a range of mixed foraging-farming strategies combining the herding of sheep and goats with hunting for wild game and the collection of local grasses and various aquatic resources (Beech et al. 2005; Potts 1997). We suspect that small groups of semi-nomadic people, practicing similar subsistence strategies, also lived along the Ur-Schatt River during this interval. As the rate of global sea-level rise decreased during the Early Holocene, the extent of transgression increased in the Arabo-Persian Gulf because of the low topographic gradients. Rapid transgression of the shoreline (~110 m per annum) caused continuous displacement of peoples and competition for optimal locations on the shifting boundary between fresh and salt-water systems. It also compressed the number of people living along this water course into a smaller area, and may have stimulated group formation or movement of people into adjacent, uninhabited environments of equal or greater economic potential.

Stage II: 8000 to 6300 BP—'Ubaid Period. We suggest that the appearance of relatively large communities in southern Mesopotamia at Eridu, Uruk, and other locations reflects an aggregation of sedentary populations adjacent to the newly formed estuaries and associated wetlands (Aqrawi 2001; Sanlaville 1989). As Oates (1960, 2004) noted, these habitats would have been ideal locations for access to fresh water, hunting/fishing of terrestrial and aquatic animals, and transportation (also see Pournelle 2003). The potential for irrigation agriculture also improved with increasing stabilization of sea level by the end of this period. In addition, it is possible that the Arabo-Persian Gulf was less saline and more productive when compared with later in time, an idea based on data from the Red Sea that suggest less saline conditions related to the displacement of the monsoonal belt existed at this time (Arz et al. 2003). Increases in the size and number of settlements in southern Mesopotamia during the early 'Ubaid Period (0–1) suggest that regional populations were expanding, a product of indigenous population growth or immigration from elsewhere in greater Mesopotamia. Several focal communities began to emerge at this time (e.g., Eridu, Tell Oueli), positioned on elevated landforms at the head of the Arabo-Persian Gulf. Settlement at several of these communities was remarkably stable through the 'Ubaid Period, a point that is best illustrated by a series of superimposed temples at Eridu (Oates 1960). The quantity of fish bone offerings found in these temples highlights the importance of aquatic habitats, at least at this location (Bottéro 2001).

The non-linear distribution of these settlements suggests that irrigation agriculture (Adams 1981) was not an essential or dominant element in the subsistence economy, although it was used elsewhere in greater Mesopotamia (Oates and Oates 1976; Wilkinson 2003). Given the humid conditions at the beginning of the 'Ubaid Period and the initial formation of productive wetlands, it seems reasonable to assume that these communities were founded upon more

diverse mixed economies that included hunting, fishing, herding, and farming (dry and irrigated fields). Given these low regional populations and favorable environmental conditions, we suggest that irrigation agriculture was not essential for the formation and stability of these early ‘Ubaid settlements. The more dispersed nature of settlement in the earliest ‘Ubaid suggests that populations were less restricted or circumscribed than later in time and that a range of habitats could sustain populations using a mixture of subsistence practices. This economic base would have been facilitated, in part, by varied habitats associated with the newly created wetland areas at the head of the Gulf and lacustrine habitats scattered across the region, related to the humid conditions of this period. In other words, as groups increased in size, impacting local habitats and competing for localized resources, there were still other economically viable options available elsewhere. This type of environmental context would have favored splintering of communities rather than integration into larger groups.

During the middle ‘Ubaid Period (‘Ubaid 2–3) certain communities grew larger in size relative to surrounding communities, and some evidence exists for differential access to resources and control of food stores by elite group members (Stein 1994). The aggregation of people at focal communities located near optimal wetland locations occurred during a period of rapid regional drying, related to the southern retreat of the South Asian monsoonal belt (Arz et al. 2003), that would have reduced the extent of lacustrine habitats in southern Mesopotamia. Sea-level also continued to rise during this interval (7 m or more [Eisenhauer et al. 1992; Fairbanks, 1989]) and the expansion of maritime trade along the western margin of the Arabo-Persian Gulf occurred within this environmental context (Carter 2002, 2003; Connan et al. 2005). At the head of the Gulf, this rise caused a marine inland transgression of at least 200 km, or ~100 m per year. In this case, low-lying areas were inundated, creating a continually changing mosaic of aquatic habitats (Pournelle 2003), and all but the most stable landforms (those occupied by communities like Eridu or Ur) were flooded. Optimal freshwater and estuarine environments continued to shift inland, displacing human populations. This dynamic mosaic would have stimulated increased competition for localized and circumscribed resources and the need to constantly redefine territorial boundaries and village locations as rapidly as within a single generation.

Larger groups formed at optimal locations, where environmental conditions created opportunities for ambitious individuals to exploit competitive advantages. These advantages ultimately formed the basis for the social and political hierarchies that emerged by the end of the ‘Ubaid Period (~6300 BP). It appears that people compared the costs and benefits of joining a larger group, and that the benefits (or perceived benefits) were greater than the available alternatives, even at the cost of economic and social subjugation. Under these conditions, the use of ideology, centered on the temple, became increasingly important for legitimizing the emerging economic/social inequities and the status of hereditary leaders. The expansion of late ‘Ubaid settlements down the western margin of the Arabo-Persian Gulf could be related to environmental, demographic, or social pressures in southern Mesopotamia that stimulated migration. It could also be related to new economic opportunities created by major improvements in irrigation-agriculture technology or the

persistence of seasonal monsoonal rains farther to the south as conditions continued to dry in southern Mesopotamia.

Stage III: 6300 to 5000 BP—Uruk Period. The Uruk Period represents the culmination of earlier developments leading to the first fully urban state-level society by ~5000 BP (Late Uruk or LC5 [Crawford 1991; Nissen 1988, 2000, 2001; Rothman 2004; Wright and Johnson 1975]). Populations increased in southern Mesopotamia during the 'Ubaid to Uruk Period transition (~6300 BP). This demographic trend tracks the expansion of irrigation agriculture, as indicated by the greater occurrence of canals dating to this time and of linear settlement patterns suggesting that communities were becoming more reliant on these important systems (Adams 1981). Increased food surpluses provided a firmer basis for expanding populations and a growing, socially stratified society that included administrators, craftspeople, and other specialists. We also suggest that population expansion during the Uruk Period was no coincidence. Demographic growth was favored by improving irrigation technology coupled with high water tables and the expanding floodplains linked to the deceleration of sea-level rise.

The near-stabilization of sea level also favored further enlargement of towns optimally located on the margins of the expanding wetlands at the head of the Arabo-Persian Gulf. Textual evidence indicates that Eridu and Ur were located on the coast about 5000 BP (Lambeck 1996; Larsen and Evans 1978; Sanlaville 1989). Archaeological evidence suggests that during the 'Ubaid Period, communities in the Eridu and Tell Oueli regions became increasingly maritime (Huot 1989). Even the later Sumerians (~4500 BP) are considered to have been a maritime culture (Falkenstein 1951; Jacobsen 1960). Boat transportation significantly increases the efficiency with which people can deliver resources (agricultural or otherwise) to central places (Ames 2002). Maritime transport would therefore have helped mobilize food surpluses to focal communities such as Eridu or Ur. The combination of fishing and farming also provided a powerful economic engine for population expansion, while maritime voyages to distant locations facilitated the exchange of ideas and provided exotic goods consumed by emerging elites. Exotic materials served as important status markers and reinforced the existing social and political hierarchy.

In this environmental, demographic, and social context, the settlement of Uruk-Warka emerged as a dominant regional center. First established in the 'Ubaid Period, this community grew in size during the Uruk Period, with the most pronounced growth between ~5500–5000 BP (Nissen 2001). Public architecture and the first writing systems, used primarily for information storage and accounting purposes, appeared at this time. These traits point to the existence of an elaborate administrative hierarchy governed by a supreme religious elite that controlled the economic, social, and political affairs of neighboring communities—the first urban-based state in the world. The relatively rapid growth at Uruk-Warka over 500–600 years parallels the partial abandonment of communities in northern portions of the alluvium and on the adjacent Susiana Plain. Movement of people from hinterland communities suggests that the economic and social opportunities at cities like Uruk-Warka were more attractive relative to those available elsewhere. We argue that the foundation for these opportunities was provided, in part, by the expansion of irrigation systems afforded by the

near-stabilization of sea level coupled with the infrastructural improvements developed and maintained by the new administrative hierarchy. Decreased agricultural production (e.g., dry farming) on the margins of the southern alluvium, due to increasingly dry conditions throughout Mesopotamia (Arz et al. 2003), would have attracted people to cities then supported by well-developed irrigation systems. Aridification throughout greater Mesopotamia also led to continued environmental and social circumscription in these southern cities, which heightened competition for increasingly localized resources associated with aquatic habitats. The defensive wall around the city of Uruk-Warka is suggestive of social and political instabilities that would have further favored the formation of larger groups for defensive purposes. Social instabilities and the threat of war likely contributed to the decision of many to move from hinterland to urban settings—the best available alternative even with the severe economic and social inequities inherent in the new social order. Under these conditions, people were attracted to these new urban centers and accepted the ideological system established by the ruling elite to legitimize their elevated positions. Population expansion and the replication of the Uruk social system fostered its expansion into northern Mesopotamia, where Uruk outposts were established to gain additional resources and where similarly organized state-level societies emerged.

CONCLUSIONS

We argue that urbanism and cultural complexity in southern Mesopotamia resulted from a series of decisions by many people over several millennia under continuously changing environmental, demographic, economic, social, and political conditions. The aggregate effect of these decisions culminated in the first state-level societies in the region. Global eustatic and climate changes influenced dynamic environmental conditions in southern Mesopotamia, along with inter-related changes in human demography, economy, and sociopolitical organization.

Coastal and aquatic habitats played a critical role in shaping the cultural evolutionary history of the region. The earliest stable settlements were established adjacent to newly formed and productive estuaries and associated wetlands as the marine transgression slowed between 8000 and 6300 BP—the ‘Ubaid Period. These locations were optimally located near fresh water and diverse aquatic habitats, and were ideally positioned for efficient transport of goods and people using watercraft. Small-scale irrigation agriculture could also have been employed along wetland margins where water tables were higher. People living in more marginal parts of southern Mesopotamia moved into larger communities because this action either maintained or improved their economic well-being, even in the face of subjugation by emerging elites.

Continued population growth occurred in southern Mesopotamia during the ‘Ubaid to Uruk transition (~6300 BP) as sea-level rise decreased significantly between 6300 and 5500 BP. A deceleration in marine transgression stimulated the expansion of floodplains in southern Mesopotamia and the formation of the high water table necessary for large-scale, floodplain irrigation agriculture. Increased food surpluses resulting from irrigation agriculture provided the basis for expanding populations and the developing socio-political structure. Increasing aridity in southern Mesopotamia between 6200 and 5000 BP contributed to further circumscription of populations, increased

competition for favorable land and water resources, aggregation of populations in centers close to the rivers and estuaries, greater reliance on irrigation agriculture, and to the need for the development of larger population centers for defensive purposes. It is within this context that the important city of Uruk-Warka emerged at the center of the first urban-based state between 5500 and 5000 BP.

ACKNOWLEDGEMENTS

We appreciate the general support of the National Science Foundation (Archaeology, and Marine Geology and Geophysics). We thank Dale Krause for encouragement and valuable suggestions; Walter Pitman for initial stimulation; David Hodell for suggestions regarding climate/orbital relations; and Frank Sirocko for providing sediment data. We also thank Robert McC. Adams, Mark Aldenderfer, Geoff Bailey, Jon Erlandson, Brian Fagan, Scott Fitzpatrick, Michael Glassow, Michael Jochim, Sarah McClure, Joan Oates, John Orbell, Dan Potts, Katharina Schreiber, Bruce Winterhalder, and Herbert Wright for useful information and/or suggestions that helped improve this paper. Several anonymous reviewers also provided valuable constructive criticism.

END NOTES

1. This manuscript was initially prepared in response to a talk given by Walter Pitman, in which he traced biblical flood mythology to the rapid inundation of the Black Sea during the Holocene, an idea he later published in the book *Noah's Flood*: *The New Scientific Discoveries About the Event That Changed History* (Ryan and Pitman 1998). Although it is inherently difficult to trace the development of mythology to past cultural and environmental events, we argue, based on the environmental and cultural history of southern Mesopotamia, that the Sumerian flood myth (as recorded in the Gilgamesh Epic) and the succeeding biblical flood narrative, most likely have their origins in the glacioeustatic latest Quaternary transgression in the Arabo-Persian Gulf, the largest, shallowest inland sea contiguous with the ocean. Flood mythology among maritime societies is virtually universal (see the essay "Flood Stories from Around the World." Published at http://www.talkorigins.org/faqs/flood-myths.html) and is most likely linked with eustatic rises in sea level during the Late Pleistocene and Early Holocene. As Teller et al. (2000) point out, a rapid marine transgression occurred in the Arabo-Persian Gulf during this period and likely displaced people living along this waterway. Such momentous events were surely passed down orally for generations. What makes southern Mesopotamia unique compared with other parts of the world is that writing developed early in association with the formation of state-level societies, so the flood story was ultimately recorded, formally as in the well-known Epic of Gilgamesh. Following Occam's razor, we hypothesize, as do Teller et al. (2000; see also Potts 1996), that the origin of biblical flood mythology is most likely in southern Mesopotamia rather than in the vicinity of the Black Sea.
2. These habitats were highly productive and not comparable with the infilled wetlands of lower productivity historically inhabited by "Marsh Arabs" (Ochsenschlager 2004). We argue that this lifeway has been used incorrectly as ethnographically analogous to that of early human populations living at the head of the Gulf.
3. The boundary between the 'Ubaid and Uruk periods is provisionally placed at ~6300 BP based on the recalibration of radiocarbon dates for Uruk-related assemblages in greater Mesopotamia (Wright and Rupley 2001) and on personal communication with Joan Oates, who has suggested that the boundary date between 'Ubaid and Uruk is sometime before ~6200 BP. However, the boundary could be as early as 6700 BP in some locations (Hole 1994).

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